A low cost coarse/fine piezoelectrically actuated microgripper with force measurement.

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Abstract

The last decade was characterized by an important increase in the request concerning miniature products. Nowadays, the miniaturization of the products represents major strategic and economic stakes. Economic surveys expect an important increase in the needs for MEMS (Micro Electro Mechanical Systems) and MOEMS (Micro Opto Electro Mechanical Systems) in various fields. Components used in MEMS are different from those used in microelectronics technology. Micromanipulation of flat SMD (Surface Mounted Devices) electronic components has been successfully done using vacuum handling systems. However, components used in MEMS have electrical, mechanical, optical or fluidic functions. These components have complex 3D shapes. This is why new micromanipulation technologies must be developed taking into account the specificities of these new components.

One of the most important functions is the gripping of microcomponents. In order to fulfil the demands concerning microhandling, various laboratories have developed prototypes of microgrippers. Most of them are able to handle micro-objects in a narrow range of sizes. Moreover, these grippers are rarely equipped with precise sensors for force measurement. However, measuring the force applied by the gripper on the manipulated object is very important in order to avoid damaging or destroying the object.

In this paper we present the design and the control of a microgripper dedicated to very high precision tasks. This microgripper is able to handle small components in a wide range of sizes (from 100 µm to several mm). The object handled can be moved laterally on several cm with force control.

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1 Structure of the system

In order to handle micro-objects in a wide range of sizes, the designed microgripper is made up of two separate parts. Each part is composed of a coarse positioning device using piezoelectric actuators and a piezoelectric bending cantilever for fine positioning (one finger of the gripper) (see Fig. 1). The coarse positioning device uses the stick-slip actuation mode in order to offer a theoretically unlimited displacement while the fine positioning is obtained by applying a voltage to the cantilever. The cantilever is made up of two PZT (lead zirconate titanate) layers equipped with electrodes. In order to measure the force applied on the manipulated objects, two small strain gauges are glued on the bending cantilever (one on every side). Other principles are also possible [1][2][3].

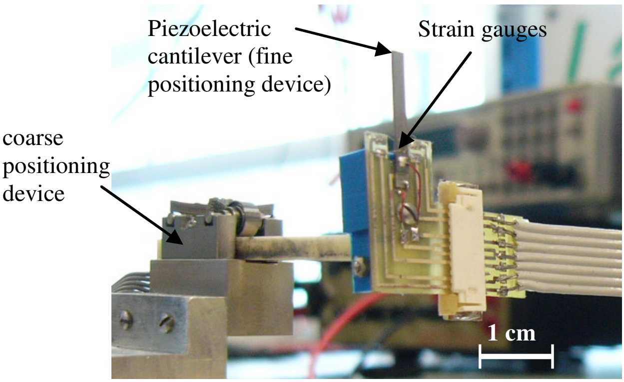

Figure 1: Structure of one part (half of the gripper)

2 Position control

The position control of the tip of the cantilever requires two steps:

First, the coarse positioning system is actuated to approach the target position.

Second, a voltage is applied on the cantilever in order to perform the fine positioning.

Combining these two actions, a wide range (several centimeters) and a high accuracy (about 20 nm) are obtained. The control signals are generated using a personal computer (PC) equipped with a dSPACE input/output board.

3 Force measurement

The strain gauges are included in a Wheatstone bridge. The output signal of the bridge is amplified and filtered. The final signal is used to measure the deflection of the cantilever and then the force applied at the tip. This low cost measurement system has been calibrated using a 10 nm resolution laser position sensor (from KEYENCE). Figure 2 shows a measurement signal obtained using the gauges. The resolution obtained is 1mN.

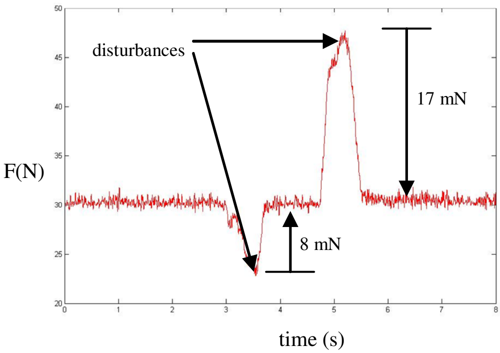

Figure 2: Force measurement using strain gauges

4 Force controlled gripping tasks

The control of the gripping force has many applications. First, it allows avoiding damages or destruction of the manipulated object. Second, the object is gripped firmly during transport. Third, mechanical characteristics of the object can be obtained (for example: elasticity). The designed microgripper was used to perform several manipulation tasks. Figure 3 was extracted from a sequence of handling where a 2mm sized component was gripped and transported along several centimeters. The left finger is controlled in position in order to move the object while the right finger is controlled in force. The force applied on the object is sufficient to prevent the release of the object without exceeding force limit.

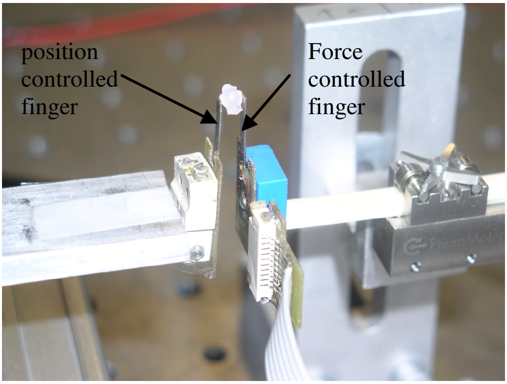

Figure 3: force controlled handling of a small component (size: 2mm)

5 Conclusion

In this paper, we have presented a concept of gripper using two separate parts. Each part moves one finger. This approach permits the use of a single gripper to perform various high precision manipulation tasks. Small components of various sizes can be handled. The use of a coarse/fine configuration allows performing gripping and carrying of the components. Force measurement is done using a low cost measurement system based on strain gauges. The resolution obtained (1 mN) is compatible with high precision assembly. Compactness of the whole system makes it suitable for integration in precision assembly processes.

Future work will deal with the integration of the control algorithmes inside a SMD microcontroller to obtain a smart autonomous gripper.

References:

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